Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 30 (2012) 861 – 868

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Communication Technology and System Design 2011

Recognition of Tamil Sign Language Alphabet using Image Processing to aid Deaf-Dumb People

P. Subha Rajam[a], G. Balakrishnan[b] , a*

[a]*IT Dept., J.J. College of Engineering & Technology, Trichy, Tamilnadu, India.*
[b] *Indra Ganesan College of Engineering, Trichy, Tamilnadu, India.*

Abstract

This paper proposes a method that provides the conversion of a set of 32 combination of the binary number 2^5 which represents the 'UP' and 'DOWN' positions of fiver fingers into decimal numbers. For the conversion of binary numbers, Palm Extraction method, Feature point extraction method, training phase and testing phase are used. The static and dynamic images can be converted by these methods. Then the binary numbers are converted into decimal numbers by using Binary-Decimal conversion algorithm and then the decimal numbers are converted into corresponding Tamil letters 12 vowels, 18 consonants and 1 Aayutha Ezhuthu (ஆய்த எழுத்து).

Keywords— Tamil Sign Language Recognition System; Image processing; Pattern recognition; Feature Point Extraction and Binary conversion into Tamil letter.

1. Introduction

Language is the prime means of communication of people. Sign is the oldest way of communication of the primitive man when there is no proper language. Nowadays the sign language is also preferred among the deaf-dumb people. Possibilities are very less in understanding the sign language of the deaf-dumb people by normal people in such places like bank, booking counters etc. Conversion of sign language into text or voice reduce the problems arise there. Sign Language Recognition (SLR) is a tool

* P. Subha Rajam. Tel.: +91-0431-2480826
E-mail address: subha8892@yahoo.co.in.

1877-7058 © 2011 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
doi:10.1016/j.proeng.2012.01.938

executes the conversion of sign language into text or voice. Research in SLR started two decades before all over the world especially in American and Japanese Sign languages. Some researchers mainly concentrated on the capture, recognition and classification of the gestures of sign language [1]. American [4], Australian [5], Korean [6], and Japanese [7] sign languages contributed more in this area. Many more techniques and algorithms have been proposed in using a variety of methods based on the sensor fusion signal processing, image processing, and pattern recognition methods till now. International Sign Languages including Chinese [8], and Arabic [9], [10] used these applications to some extent. There were no such contributions to Tamil Sign Language Recognition system by any of the researcher in this area. Even though many regional languages are in practice in all countries the sign language should be one. But the language varies from one country to another. This paper deals with a system which recognizes the Tamil Sign Language for human – computer interaction. To help people with such disabilities, this proposed method is able to recognize a set of 31 signs of Tamil letters 12 vowels, 18 consonants and 1 Aayutha Ezhuthu. Each representing the Static or Dynamic images of the palm side of right hand.

2. Earlier Works

Many approaches have been proposed that combine Dynamic time wrapping or Hidden Markov Models (HMMs) with discrimination classifier for recognizing speech, handwriting or Sign Language.

Starnet et al, had presented in Real time ASL recognition using vision – based approaches based on HMMs. This system involved in two proposed methods by using 40 signs. The first proposed method used a single camera mounted on a desk and obtained 92% accuracy. The second method used a camera mounted on a cap worn by the user and obtained 98% accuracy. Their methods were performed with continuous ASL data set for which only hand motion features were used [4].

Hee–Deok et al, had developed Sign Language spotting with a threshold model based on Conditional Random Fields (CRF). This involved in an adaptive threshold for differentiating between sign in a vocabulary and non sign pattern. This method performed with CRFs without threshold model, short-sign detection, sub sign reasoning and hand sign verification for recognition. The experiments were performed with continuous data set with an 87% spotting rate and recognized the signs from isolated data with 93.5% [14].

T. Shanableh developed a method for recognizing isolated Arabic sign language gestures in a user-independent mode. In this method, gloves were worn by the signers in order to simplify the process of segmenting out the hands of the signer via colour segmentation. Two different classification techniques; namely, K-NN and polynomial networks [3] were used to assess the effectiveness of the proposed user-independent feature extraction scheme. Variety of feature extraction methods for Arabic Sign Language Recognition was contributed by them. These techniques used temporal and spatial domain in order to capture the motion information of video segments i.e. image sequence into single representing image which is transformed into the frequency and parameterized into a precise and concise set of features and compared with other classical techniques [10]. A variety of special devices were utilized to recognize the Sign Language [12] [13]. Hand shape and motion were extracted accurately and easily by these devices. However, the expense is more and naturalness of Sign Language communication is low.

3. Proposed Methodology

In the proposed method, 32 combinations of binary images each representing ‘UP’ and ‘DOWN’ position of 5 fingers are converted into 12 vowels, 1 Aayutha Ezhuthu and 18 consonants of Tamil letters as shown in the Fig 1.

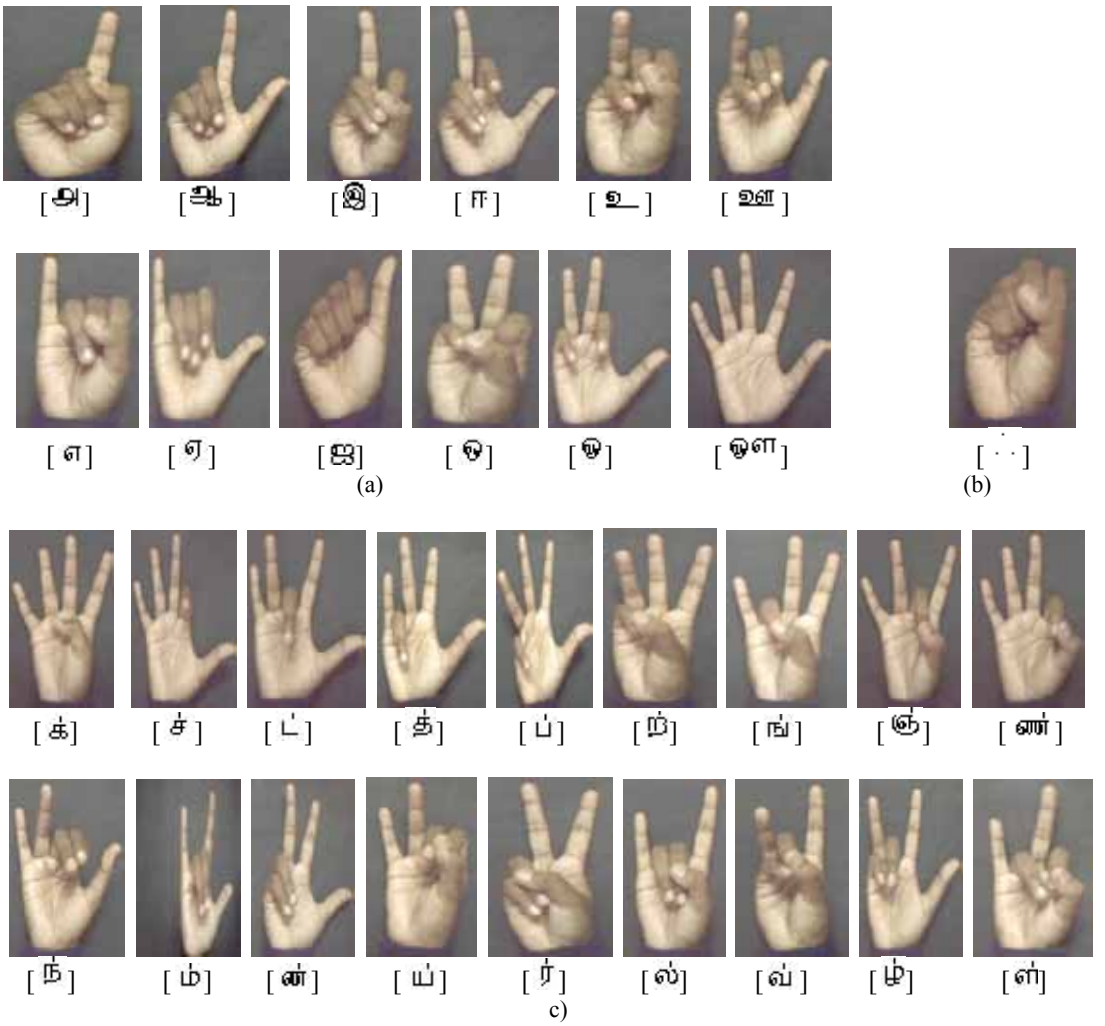

Figure 1. 32 combinations of binary number sign to Tamil letters
a) 12 Vowels b) 1 Aayutha Ezhuthu c) 18 Consonants

Each image is taken through web camera in different positions for 10 times. Thus we obtained 320 images. All these images are stored in a separate directory. This may be manipulated in two types of

1. Static image Sign Recognition system [11].
2. Dynamic image Sign Recognition System [15].

These two methods need Data Acquisition, Palm Image Extraction, Feature Point Extraction, Training Phase and Testing Phase for the conversion. These processes are shown in the Fig. 2.

3.1 *Data Acquisition*

The background is to be arranged in a black colour before taking right hand palm images. A black band is to be worn on the wrist and the distance between the hand and web camera is to be maintained in 1 to 3 feet.

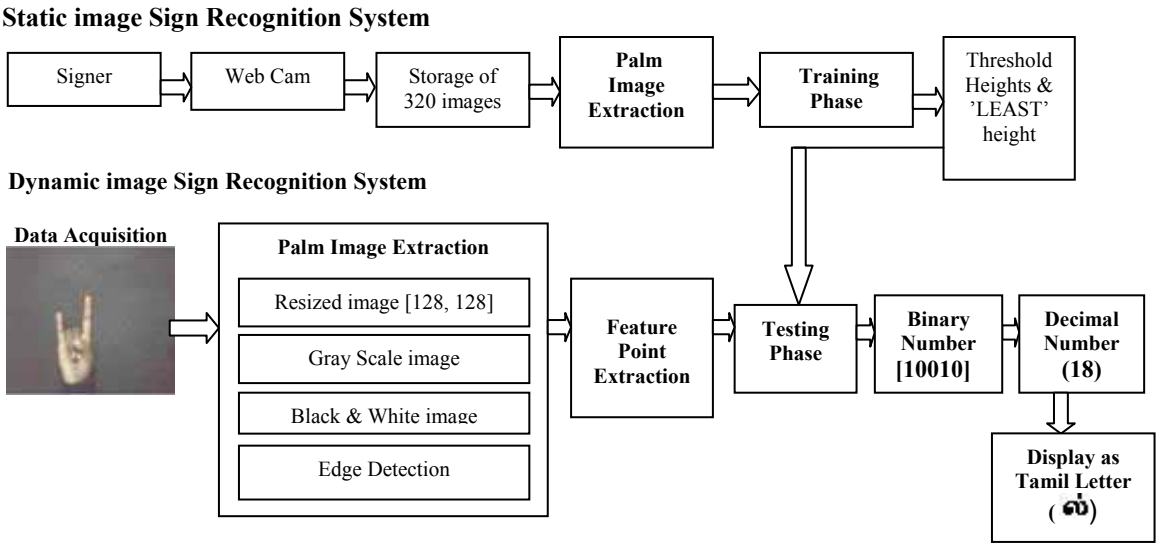

Figure 2. Proposed Methodology

3.2 *Palm Image Extraction*

The captured images are resized to a resolution of 128 x 128 pixels as shown in Fig 3 (a). The images in RGB colour are converted into Gray scale images which are in turn converted into black and white images. The images are then processed using Canny Edge Detection technique to extract outline images (edge) of palm as shown in Fig 3 (b). It is easier to use those edge images for extracting the finger tip position for further processing.

3.3 Feature Point Extraction

When the image is applied into Palm Extraction method, finally it changes into edge images. Every pixel in that image is '0' or '1'. To identify the position of straight finger position of the edge image Left-Right and Right-Left scan method is used. When the scan processing started from (0, 0) position of edge image row by row up to (0,127) we get a white pixel (x_1, y_1) at any position. The difference of the height between this point and fixed reference point (x_0, y_0) colour is set in red colour at the bottom-up approach. This is calculated by using *Euclidean Distance* formula as in

$$\textit{Euclidean distance} = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2} \tag{1}$$

Point (x_1, y_1) is finger tip position and (x_0, y_0) is wrist hand position (Reference Point). It is considered when the height is above the particular value and stored in an array *H* variable and also the resized image of (x_1, y_1) is set in the colour of green. If the height is below the 'LEAST' value, it may not be considered.

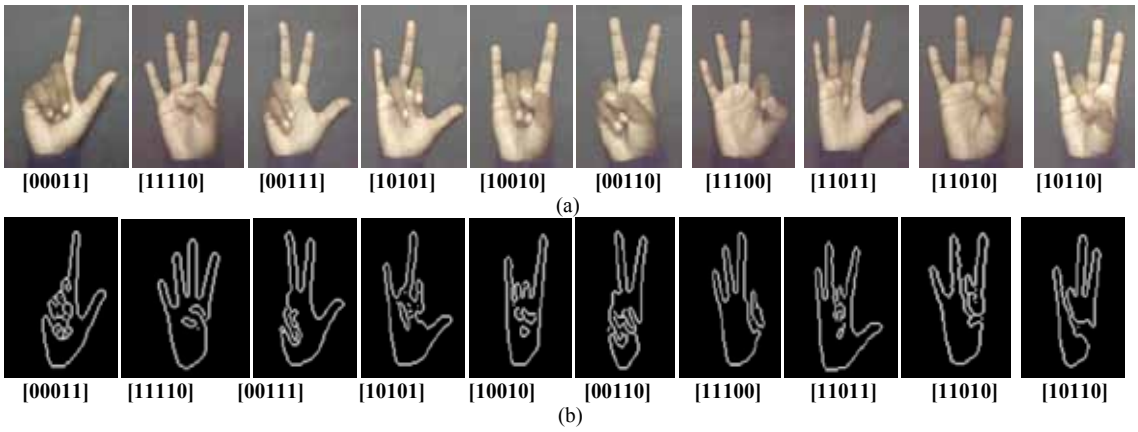

Figure 3. Sample images of 32 signs
a) Original images (b) Edge images

Then the process continued until the capture of any white pixel up to (x_1+1, y_1-8). When this is processed row by row, we may obtain 0 to 3 finger tip positions. To find out the remaining finger tip positions Right- Left scan processing can be used. After finishing scan process height values of the straight fingers in edge images are stored in an array H variable and blue colour is set in resized image of finger tip position when they are straight. To identify the straight finger (Little, Ring, Middle, Index and Thumb) from the height value, Test Phase is engaged.

3.4 Training Phase

To calculate the minimum value of each and every finger, the 320 images are used which are already stored. For example to calculate the minimum value of middle finger the following process is observed. First 5 directories L, R, M, I, and T are created. Select all the straight finger images from the 320 images and store them in the 'M' directory. Similarly all other straight finger images are stored in the respective directories. All the images are modified into edge images by the palm image extraction method. The height is calculated for the middle finger alone by scan processing. Similarly the height is calculated for all images in the directory and the minimum value is identified. Other minimum values in all directories are identified and stored in *THmin* array variable i.e. *THmin = [little, Ring, Middle, Index, and Thumb]*

3.5 Testing Phase

The height of the straight finger position in an edge image is found by feature extraction method and stored in an array H. The height of the finger which has first pixel stored in the *H(0)*. Similarly second and third white pixel stored in the *H(2)* and *H(3)*. If a single white pixel not available, it is stored as zero. In testing phase height *H(0)* obtained in the Left-Right scan is compared with all minimum heights. When compare the fingers the order should be middle, index, ring, little, and thumb finger. To compare the first white pixel height *H(0)* with THmin(2) variable i.e. If *H(0) >= THmin(2)* Then *F(2)* = 1. Five finger positions (little, ring, middle, index and thumb) values are stored in F array. If the *F(2)* is equal to one, it denotes straight middle finger position If *H(0)* is greater than *THmin(2)*, then assume that middle finger is straight so the value *F(2)* = 1. Otherwise compare with the index minimum value and so on.

If *H(0) >= THmin(2)* Then *F(2)* = 1;
Else If *H(0) >= THmin(3)* Then *F(3)* = 1;
Else If *H(0) >= THmin(1)* Then *F(1)* = 1;

```
                Else If H(0) >= THmin(0) Then F(0) = 1;
                    Then  F(5) = 1;
                     End
                End
            End
        End
```

Compare the value with other heights 0,1,2,3 finger tip position can be found out through the Left-Right scan. The remaining values can be through the Right-Left scan. Finally all the number in the F array is in the form of binary numbers. If all the fingers are straight, it will be as F = [1 1 1 1 1].

4. Conversion of Binary Number into Decimal Number

The numbers in the F array are converted into Decimal numbers by Binary to Decimal algorithm as shown below.

- Algorithm Description
  1. Establish F, the binary number is converted into the decimal number.
  2. Initialize the new decimal variable dec_no to zero.
  3. Set the power variable p to zero.
  4. Initialize i to 5.
  5. While i greater than or equal to 1 do
     a) If $F(i)$ is equal to 1
        Then compute dec_no by adding 2 ^ P to the most recent dec_no.
     b) Increment 'p' by one.
     c) Decrement 'i' by one.
  6. Write out dec_no.

5. Conversion of Decimal Number into Tamil text

The conversion of images into Tamil letters is done in the following method. Since the position of five fingers is either in a straight or in bending each Tamil letter can not form in the corresponding binary number sign image. So it is modified into an easy form to memorise when the deaf and dump people communication with others. For the Tamil letter '  ' the index finger is in the 'UP' position and for '  ' the index finger and the thumb finger are in 'UP' position. In the letter '  ' middle finger is in 'UP' position and '  ' the middle finger and thumb finger are in 'UP' position. All other letters are tabulated with a symbol as shown in Table 1.

6. Experimental results

The conversion of 32 binary sign images into Tamil letters are shown in the Fig. 5. When it is tested through static image recognition method, except 10 images out of 320 were given 96.87% sign recognition accuracy [11]. In dynamic recognition method, when the real time (5 times) of 32 images are incurred we get 160 images. Except 2 signs all the images give correct result which is 98.75% of sign recognition accuracy [15]. So the overall accuracy of both methods in this proposed method is given below

$$\text{Accuracy} = \frac{\text{No. of Patterns} - \text{No. of false result Patterns}}{\text{No. of Patterns}} \times 100\%$$

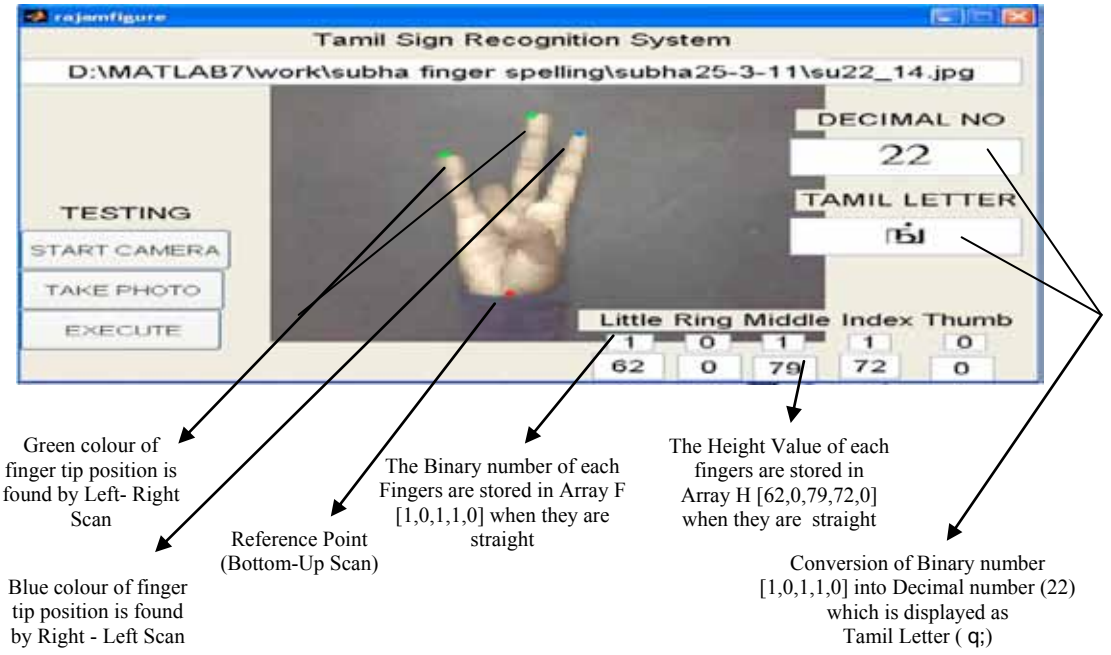

Figure 5. Sample Result of a Sign

Table 1. Conversion of Binary Number into Tamil Text

Binary Number [L,R,M,I,T]	Decimal Number	Tamil letters	Description
[00010]	02	அ	Index – 'UP'
[00011]	03	ஆ	Index & Thumb –'UP'
[00100]	04	இ	Middle – 'UP'
[00101]	05	ஈ	Middle & Thumb-'UP'
[01000]	08	உ	Ring – 'UP'
[01001]	09	ஊ	Ring & Thumb – 'UP'
[10000]	16	எ	Little – 'UP'
[10001]	17	ஏ	Little & Thumb – 'UP'
[00001]	01	ஐ	Thumb – 'UP'
[01100]	12	ஒ	Ring & Middle – 'UP'
[01101]	13	ஓ	Ring, Middle & Thumb – 'UP'
[11111]	31	ஔ	All fingers – 'UP'
[00000]	00	்	All fingers – 'DOWN'
[11110]	30	க்	Thumb – 'DOWN'
[11101]	29	ங்	Index –'DOWN'
[11011]	27	ட்	Middle –'DOWN'
[10111]	23	த்	Ring –'DOWN'
[01111]	15	ப்	Thumb – 'DOWN'
[01110]	14	ற்	Little & Thumb –'DOWN'
[10110]	22	ங்	Ring & Thumb – 'DOWN'
[11010]	26	ஞ்	Middle & Thumb –'DOWN'
[11100]	28	ஷ்	Index & Thumb –'DOWN'
[11001]	25	ந்	Middle & Index –'DOWN'
[10011]	19	ம்	Ring & Middle – 'DOWN'
[00111]	07	ன்	Little & Ring, –'DOWN'
[11000]	24	ய்	Little & Ring –'UP'
[00110]	06	ர்	Middle & Index –'UP'
[10010]	18	ல்	Little & Index – 'UP'
[01010]	10	வ்	Ring & Index – 'UP'
[01011]	11	ழ்	Ring , Index & Thumb – 'UP'
[10100]	20	ள்	Little & Middle – 'UP'

6. Conclusion

The developed 32 binary number sign images are converted into Tamil letters which has 12 vowels, 18 consonants and 1 Aayutha Ezhuthu by image processing technique. The accuracy rate is more encouraging when compared with other regional Languages. In future, experimentations need to be performed for different hand at different background and to produce the Tamil text into voice. This proposed method is very useful for the deaf and dumb people to communicate with normal people in Tamil letters.

References

[1] Aleem Khalid Alvi, M. Yousuf Bin Azhar, Mehmood Usman, Suleman Mumtaz, Sameer Rafiq, Razi Ur Rehman, Israr Ahmed T , "Pakistan Sign Language Recognition Using Statistical Template Matching," *World Academy of Science, Engineering and Technology,* 2005.

[2] Byung-woo min, Ho-sub yoon, Jung soh, Takeshi ohashi and Toshiaki jima, "Visual Recognition of Static/Dynamic Gesture: Gesture-Driven Editing System," *Journal of Visual Languages & Computing Volume10,Issue3,* June 1999, Pages 291-309.

[3] T. Shanableh, K. Assaleh, "Arabic sign language recognition in user independent mode," *IEEE International Conference on Intelligent and Advanced Systems* 2007.

[4] T. Starner, J. Weaver, and A. Pentland, "Real-Time American Sign Language Recognition Using Desk and Wearable Computer Based Video," *IEEE Trans. Pattern Analysis Machine Intelligence*, Dec. 1998, vol.20, no. 12, pp. 1371-1375.

[5] M.W. Kadous, "Machine recognition of Australian signs using power gloves: Toward large-lexicon recognition of sign language," *Proc. Workshop Integration Gesture Language Speech*, 1996,pp. 165–174,.

[6] J. S. Kim,W. Jang, and Z. Bien, "A dynamic gesture recognition system for the Korean sign language (KSL*)," IEEE Trans. Syst., Man, Cybern. B*, Apr. 1996,vol. 26, pp. 354–359,.

[7] H. Matsuo, S. Igi, S. Lu, Y. Nagashima, Y. Takata, and T. Teshima, "The recognition algorithm with noncontact for Japanese sign language using morphological analysis," *Proc. Int. Gesture Workshop*, 1997, pp. 273–284.

[8] C. Wang, W. Gao, and Z. Xuan, "A Real-Time Large Vocabulary Continuous Recognition System for Chinese Sign Language," *Proc. IEEE Pacific Rim Conf. Multimedia*, 2001, pp. 150-157.

[9] K Assaleh, M Al-Rousan, "Recognition of Arabic Sign Language Alphabet Using Polynomial Classifiers," *EURASIPJournal on Applied Signal Processing*, 2005, vol. 2005, no. 13, pp. 2136-2145.

[10] T. Shanableh, K. Assaleh and M. Al-Rousan, "Spatio-Temporal feature extraction techniques for isolated gesture recognition in Arabic sign language*," IEEE Trans. Syst., Man, Cybern. B*, 37(3), June 2007.

[11] P. Subha Rajam, Dr. G. Balakrishnan, "Indian Sign Language Recognition System to aid Deaf – Dumb People," *IEEE International Conference on Computing Communication and Networking Technologies (ICCCNT-2010),* Karur-India, pages(s):1-9, July 2010.

[12] C. Vogler and D. Metaxas, "A Framework for Recognizing the Simultaneous Aspects of American Sign Language" , *Computer Vision and Image Understanding,* 2001, vol. 81, no. 3, pp. 358-384.

[13] W. Gao, G. Fang , D. Zhao, and Y. Chen, "Transition Movement Models for Large Vocabulary Continuous Sign Language Recognition," *Proc. Sixth IEEE Int'l Conf. Automatic Face and Gesture Recognition,* May 2004,pp. 553-55.

[14] Hee-Deok Yang, Stan Sclaroff, Seong-Whan Lee, "Sign Language Spotting with Threshold Model Based on Conditional Random Fields," *IEEE Transactions On Pattern Analysis and Machine Intelligence, vol 31, no.7, July 2009.*

[15] P. Subha Rajam, Dr. G. Balakrishnan, "Real Time Indian Sign Language Recognition System to aid Deaf – Dumb People," 13th *IEEE International Conference on Communication Technology (ICCT), Sep 2011,* Secretary General School of Information Science and Engineering, Shandong University, Jinan, Shandong, China.